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(54) **AIRBAG INFLATOR MOUNTING APPARATUS, METHODS, AND SYSTEMS**

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B60R 21/217 (2011.01)

(52) **U.S. Cl.**
CPC ***B60R 21/217*** (2013.01)

(58) **Field of Classification Search**
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USPC 280/728.2
See application file for complete search history.

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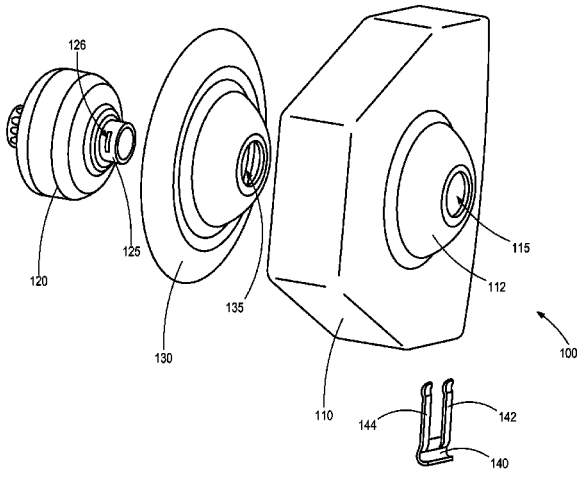
(57) **ABSTRACT**

Methods, apparatus, and systems for coupling an airbag inflator with a housing, such as an airbag module housing or an adapter housing configured to be coupled with an airbag module housing. In some implementations, a housing comprising an opening may be provided. An inflator comprising a collar may be positioned in the housing such that the collar of the inflator extends into, or in some cases through, the opening of the housing. The inflator may be fixedly coupled with the housing by engaging an exterior surface of the inflator collar with at least one engagement structure, such as a retainer clip or crimp formed in a collar sleeve of the housing.

29 Claims, 17 Drawing Sheets



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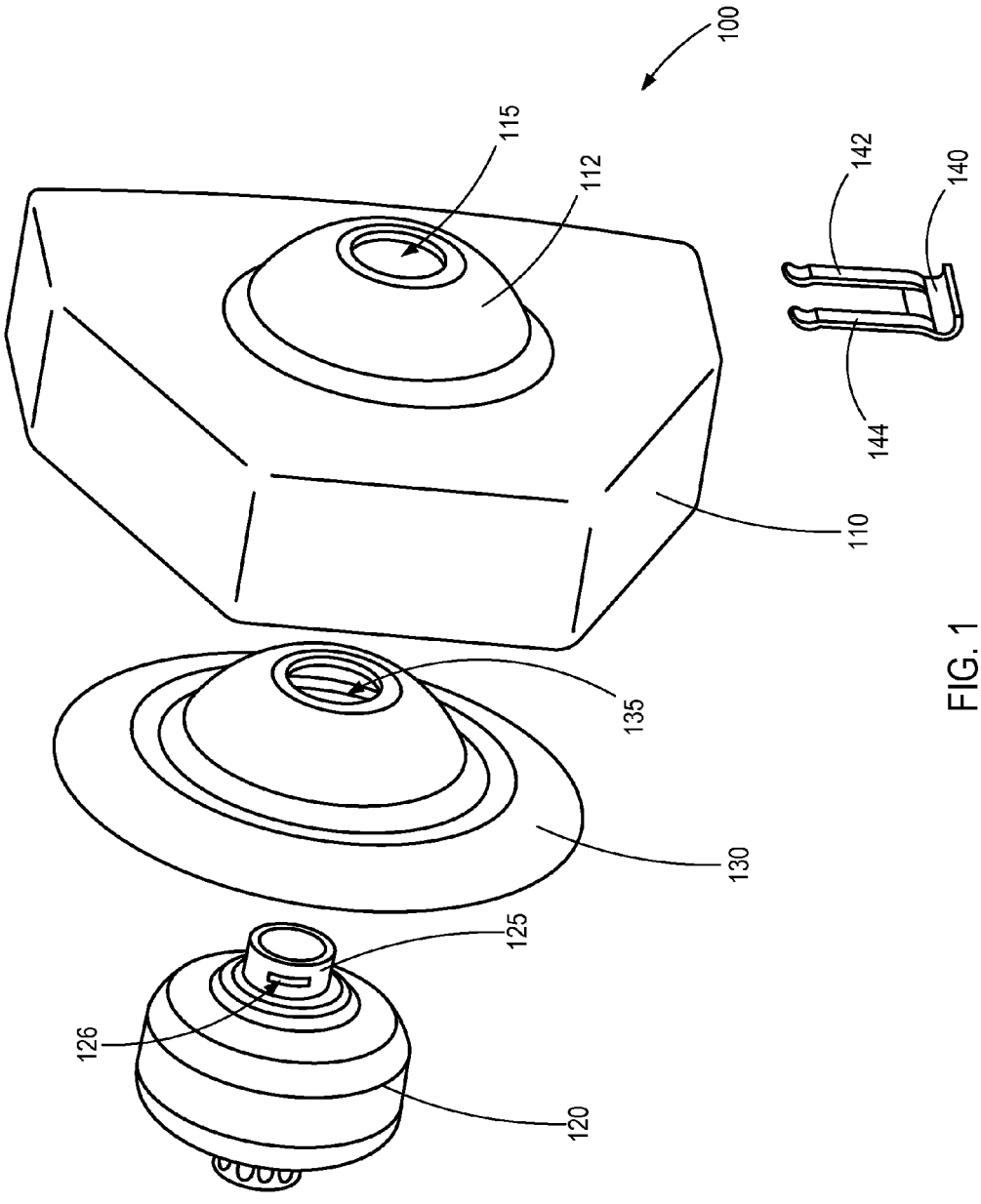

FIG. 1

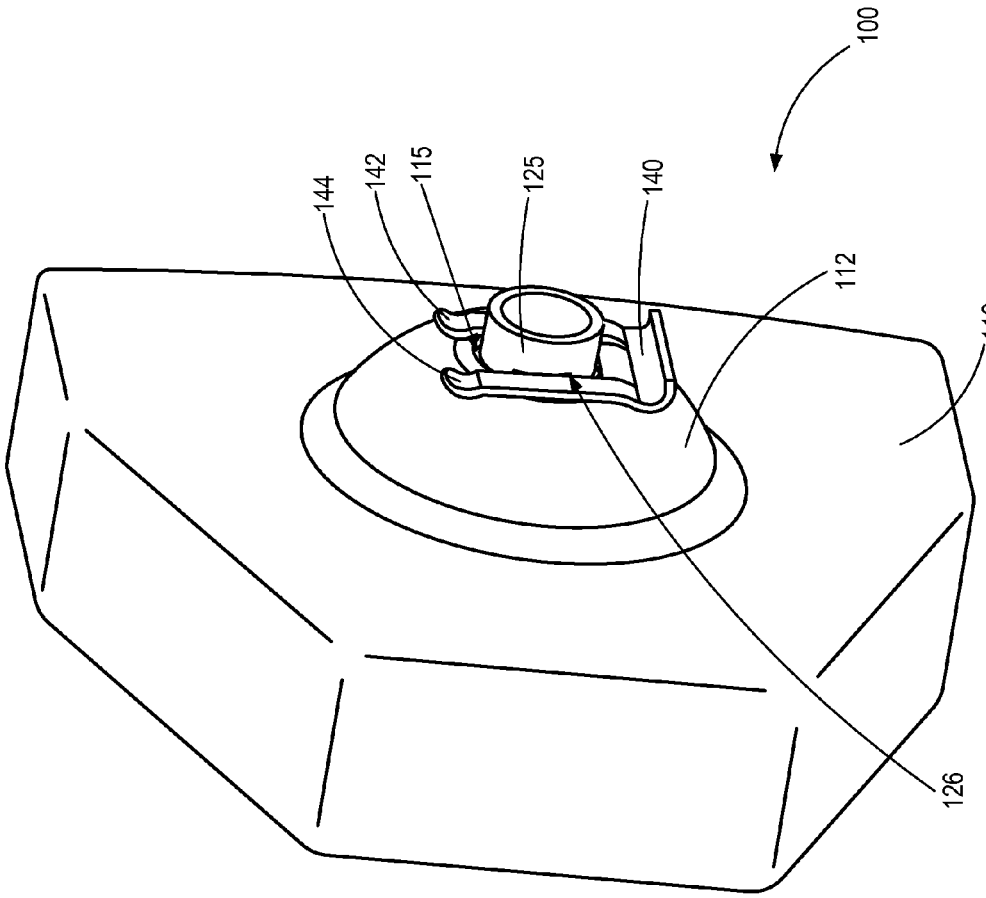

FIG. 2

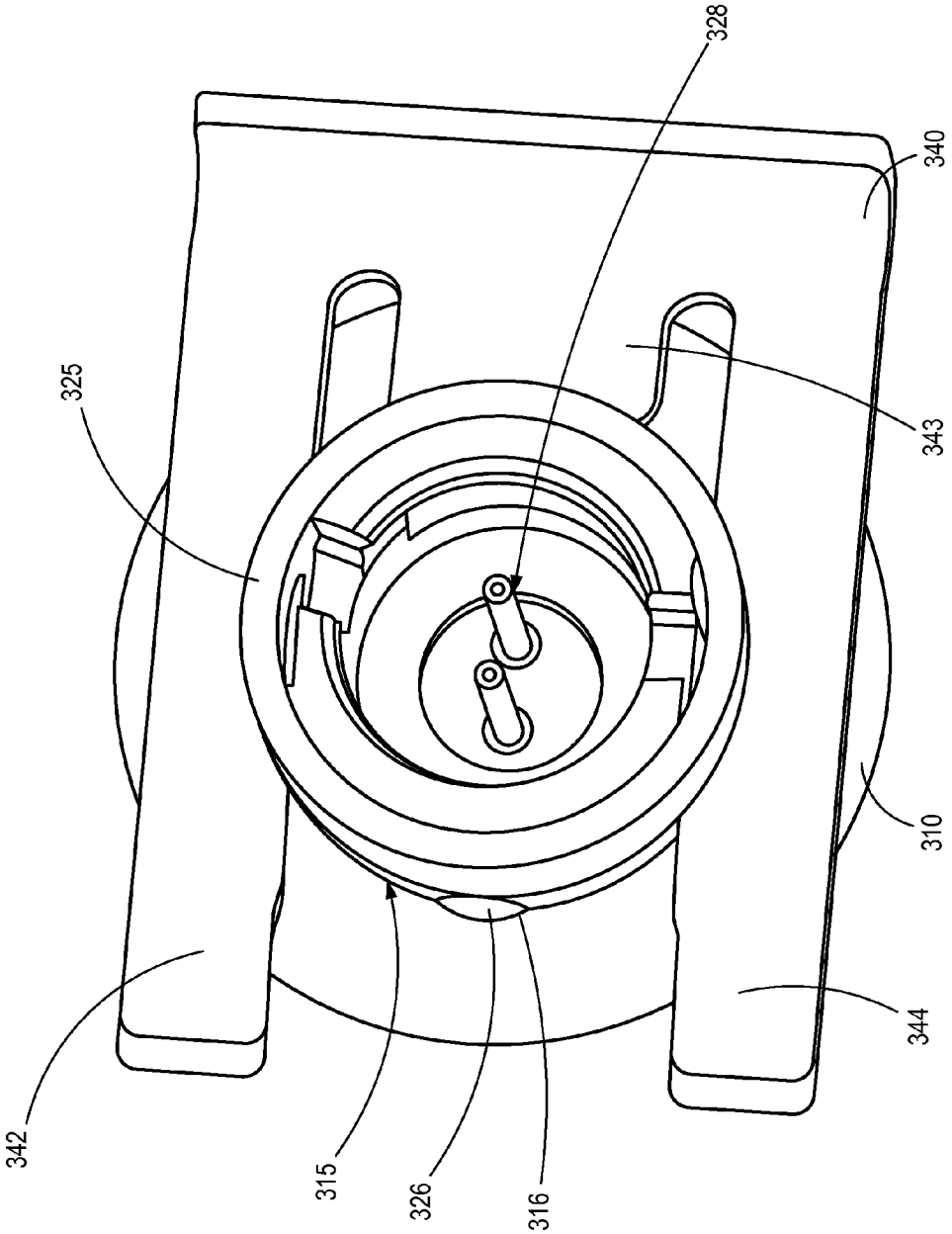

FIG. 3

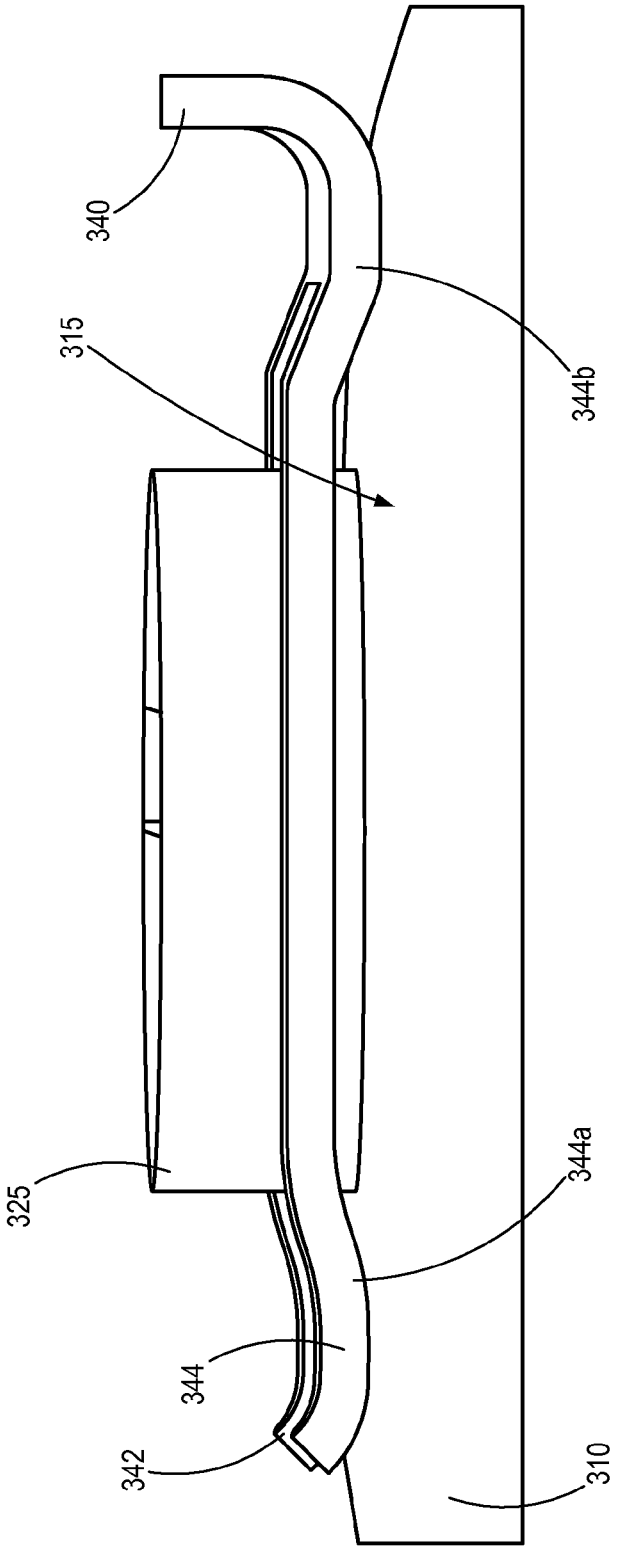

FIG. 4

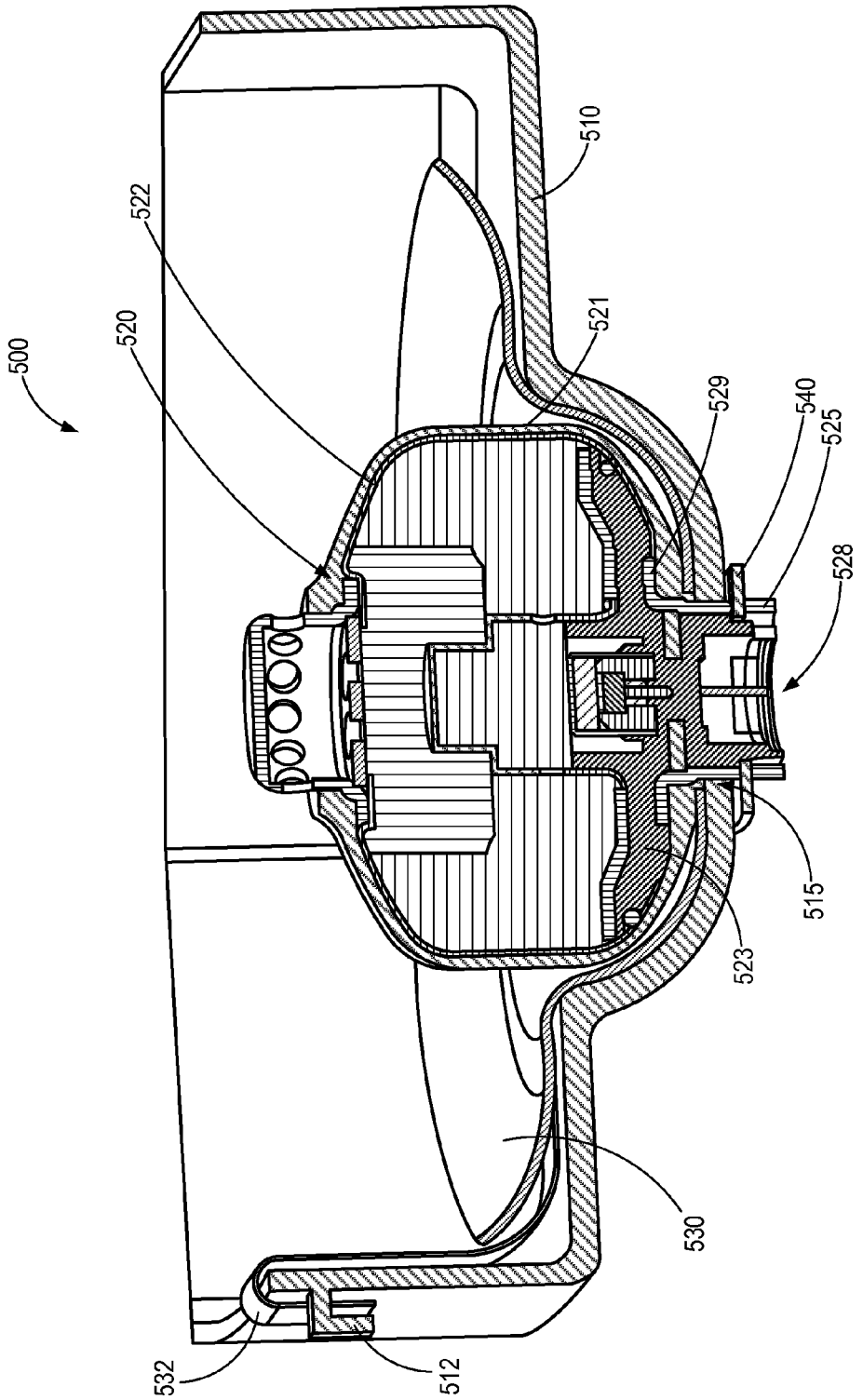

FIG. 5

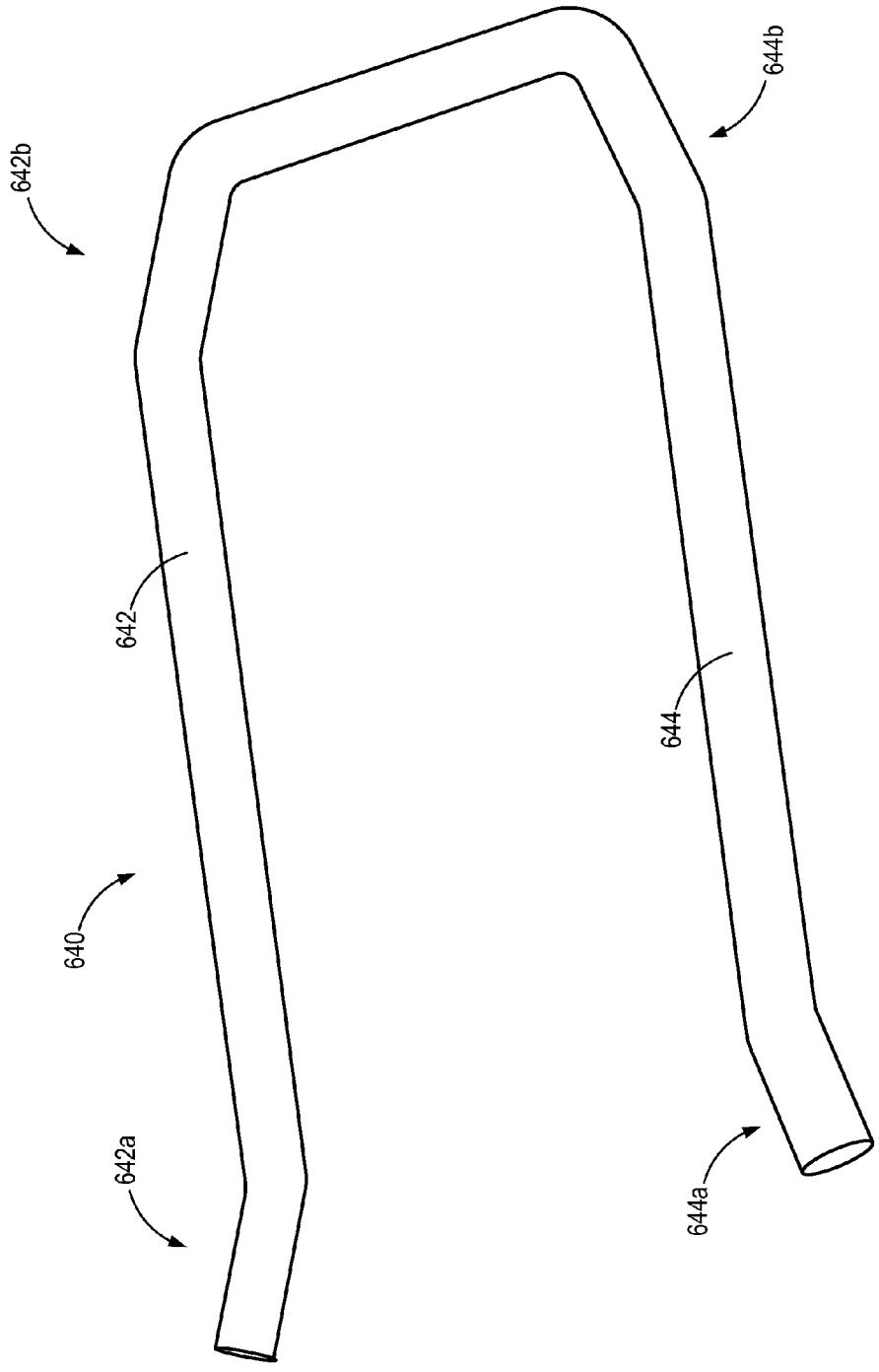

FIG. 6

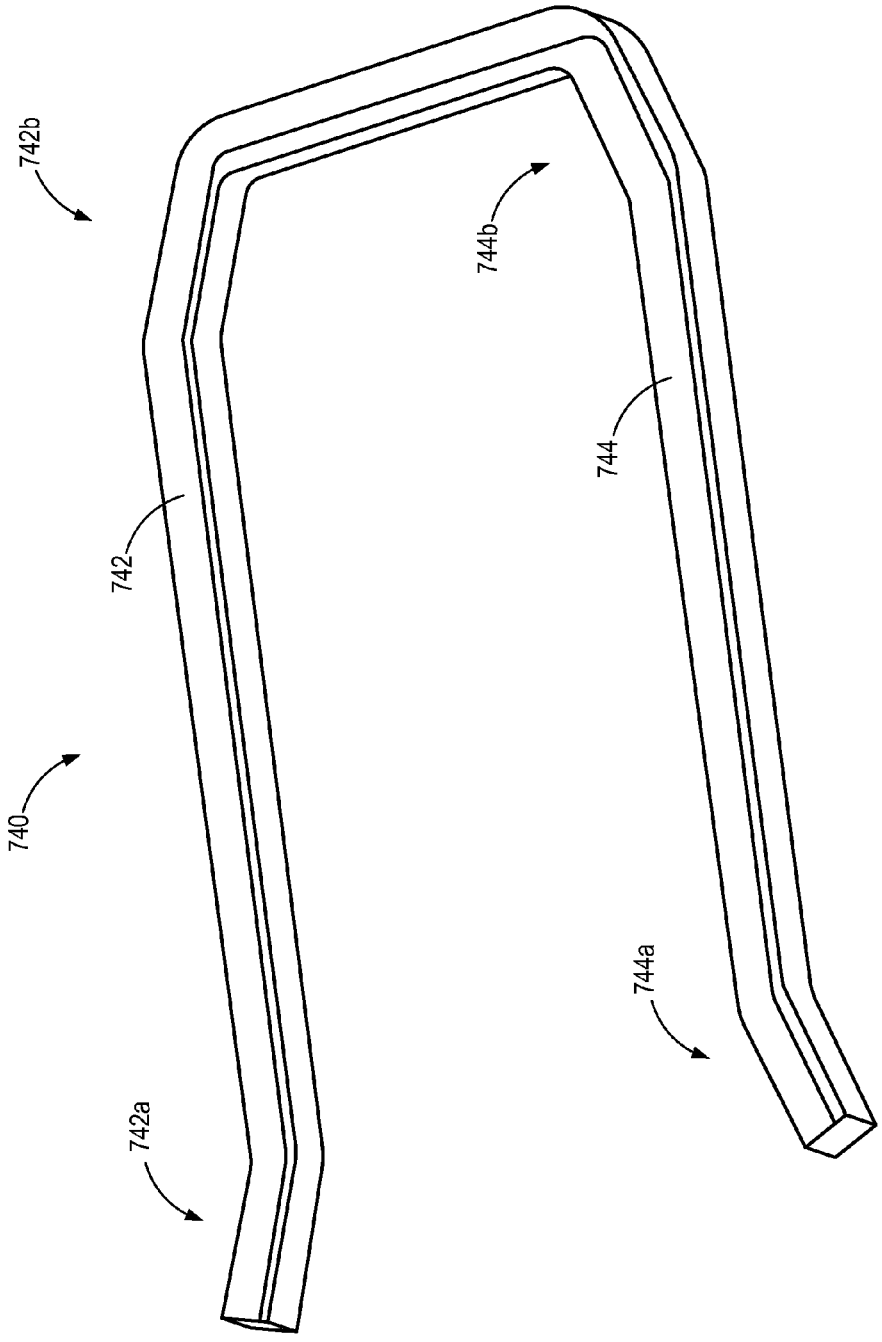

FIG. 7

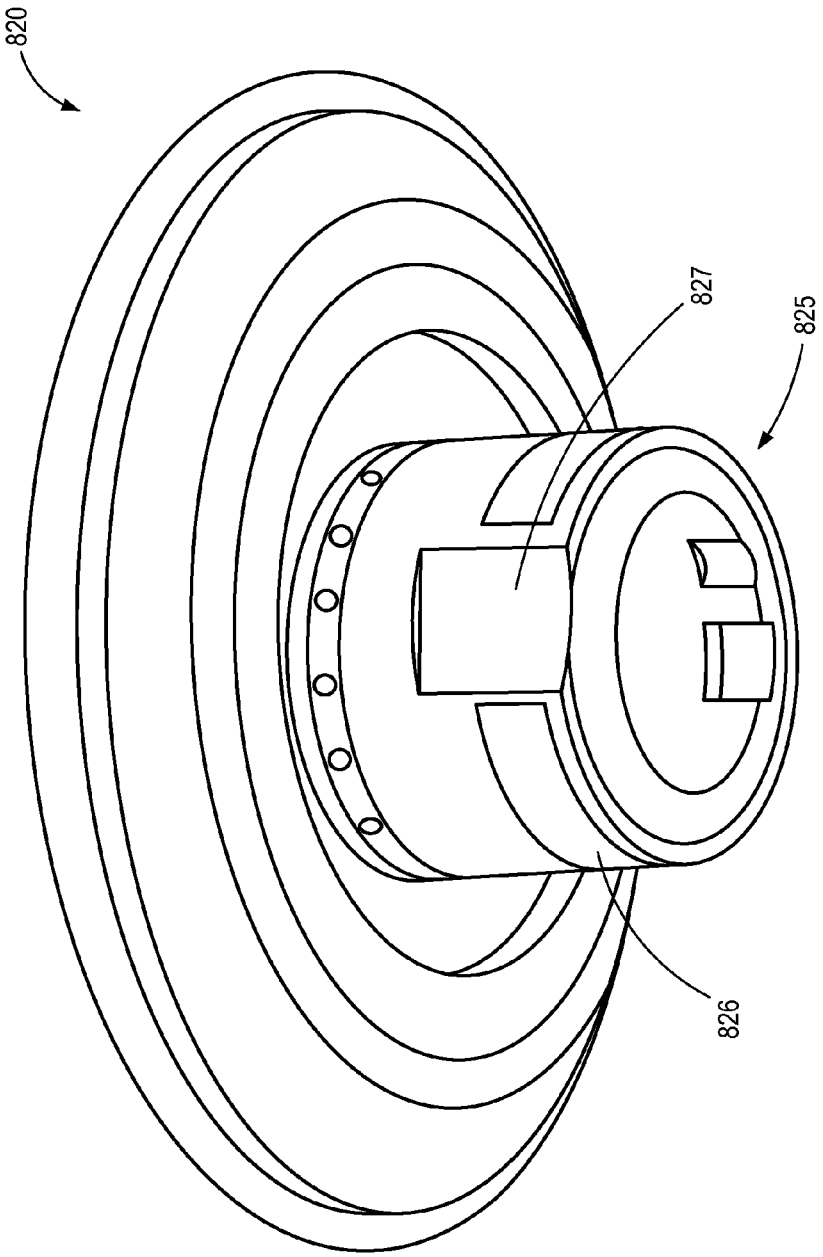

FIG. 8

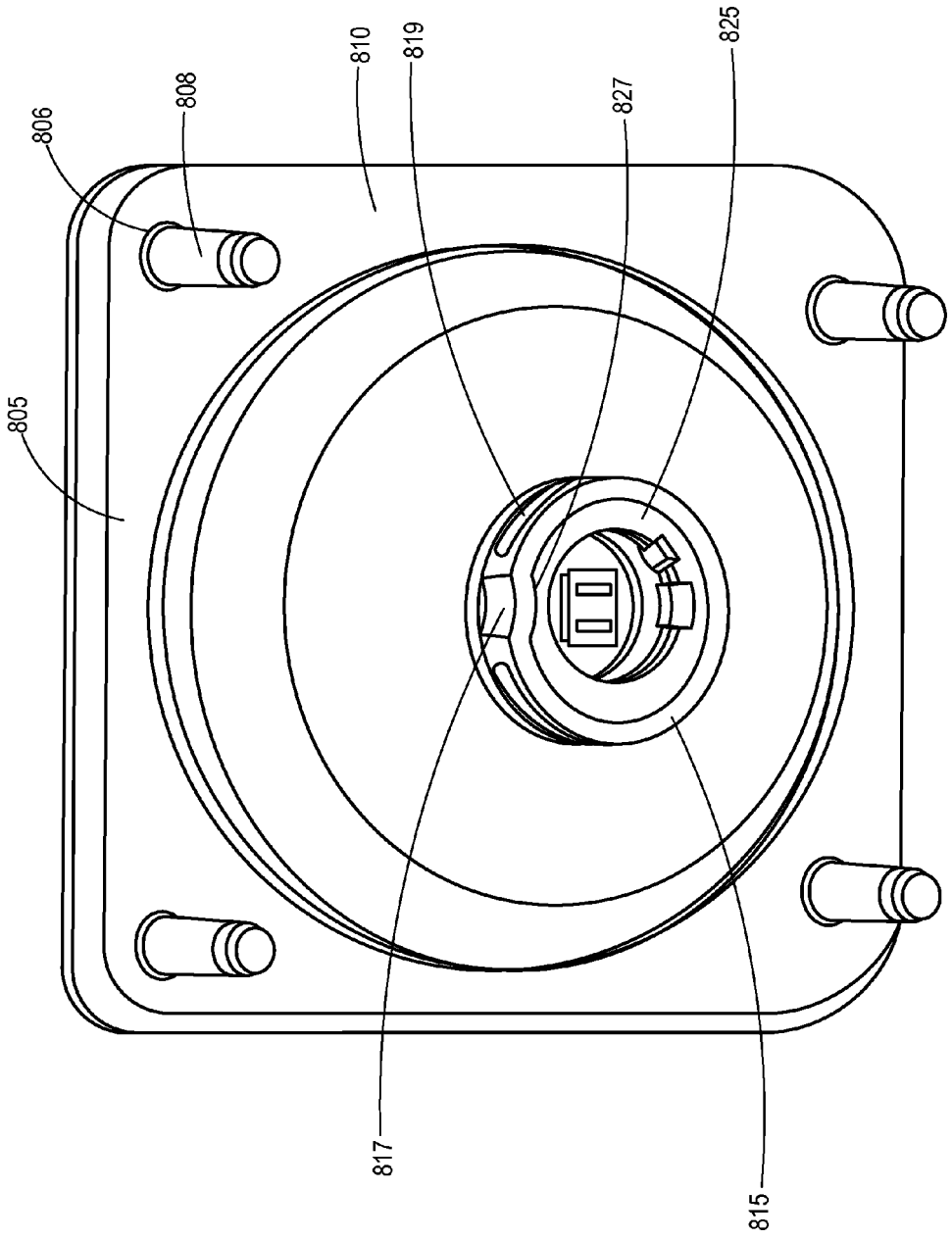

FIG. 9

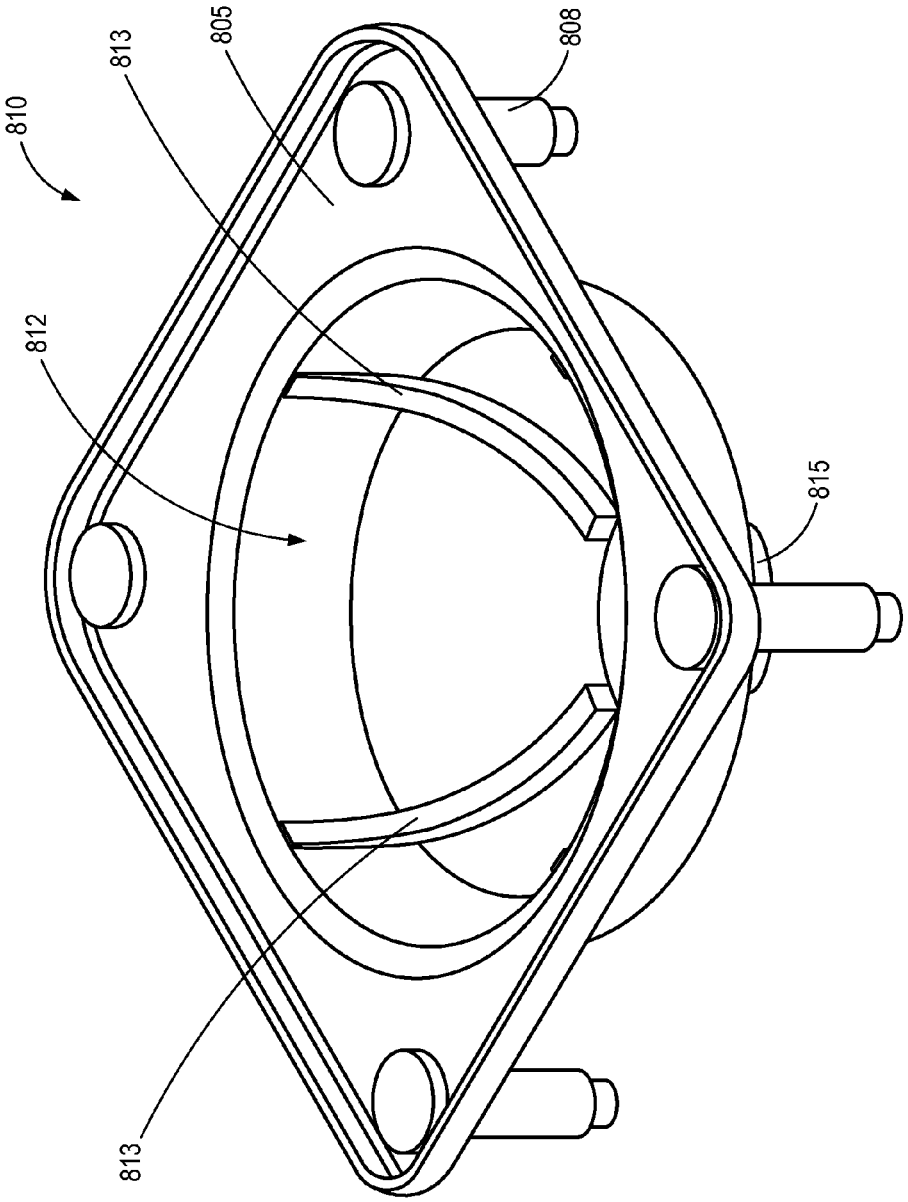

FIG. 10

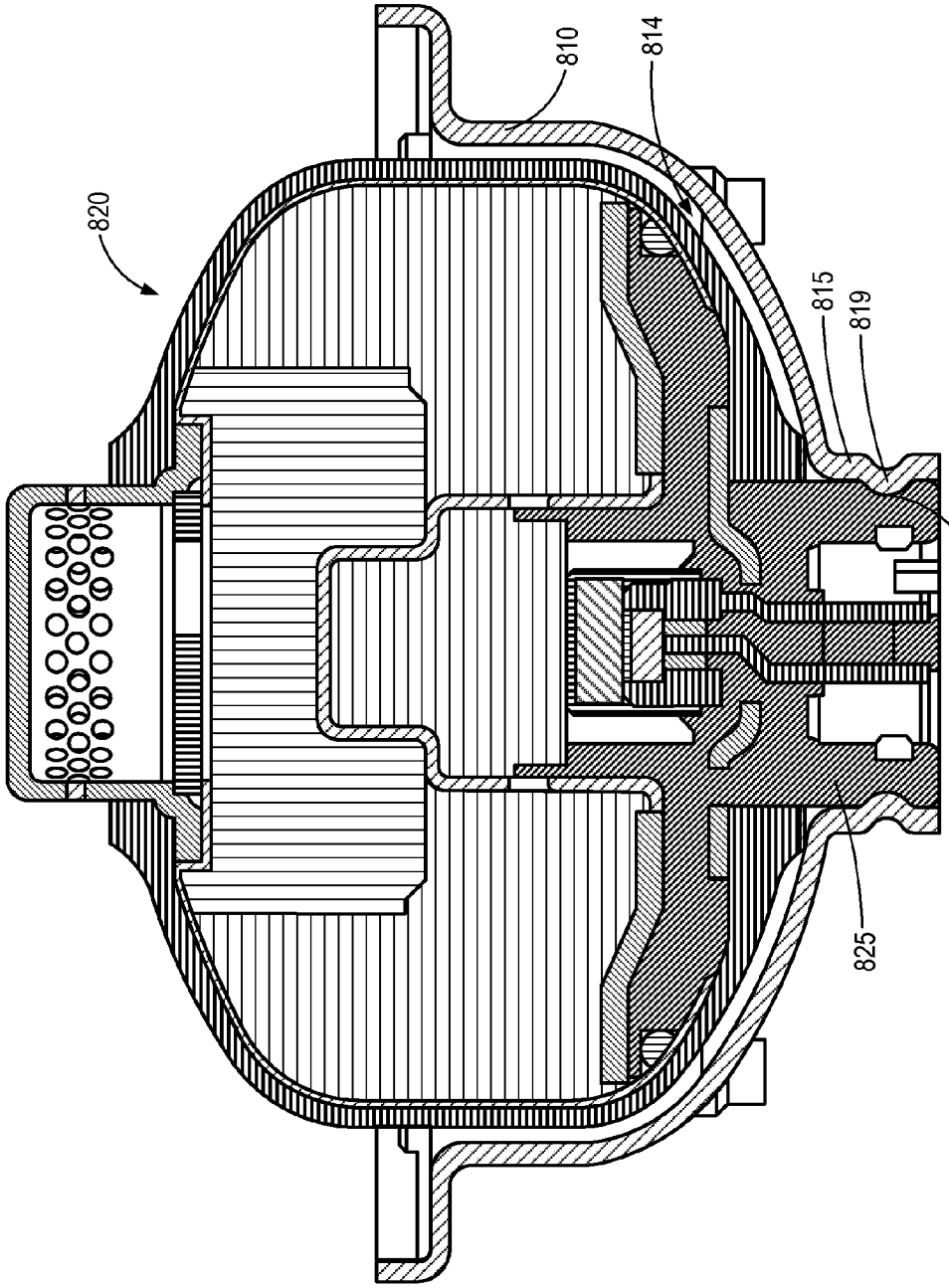

FIG. 11

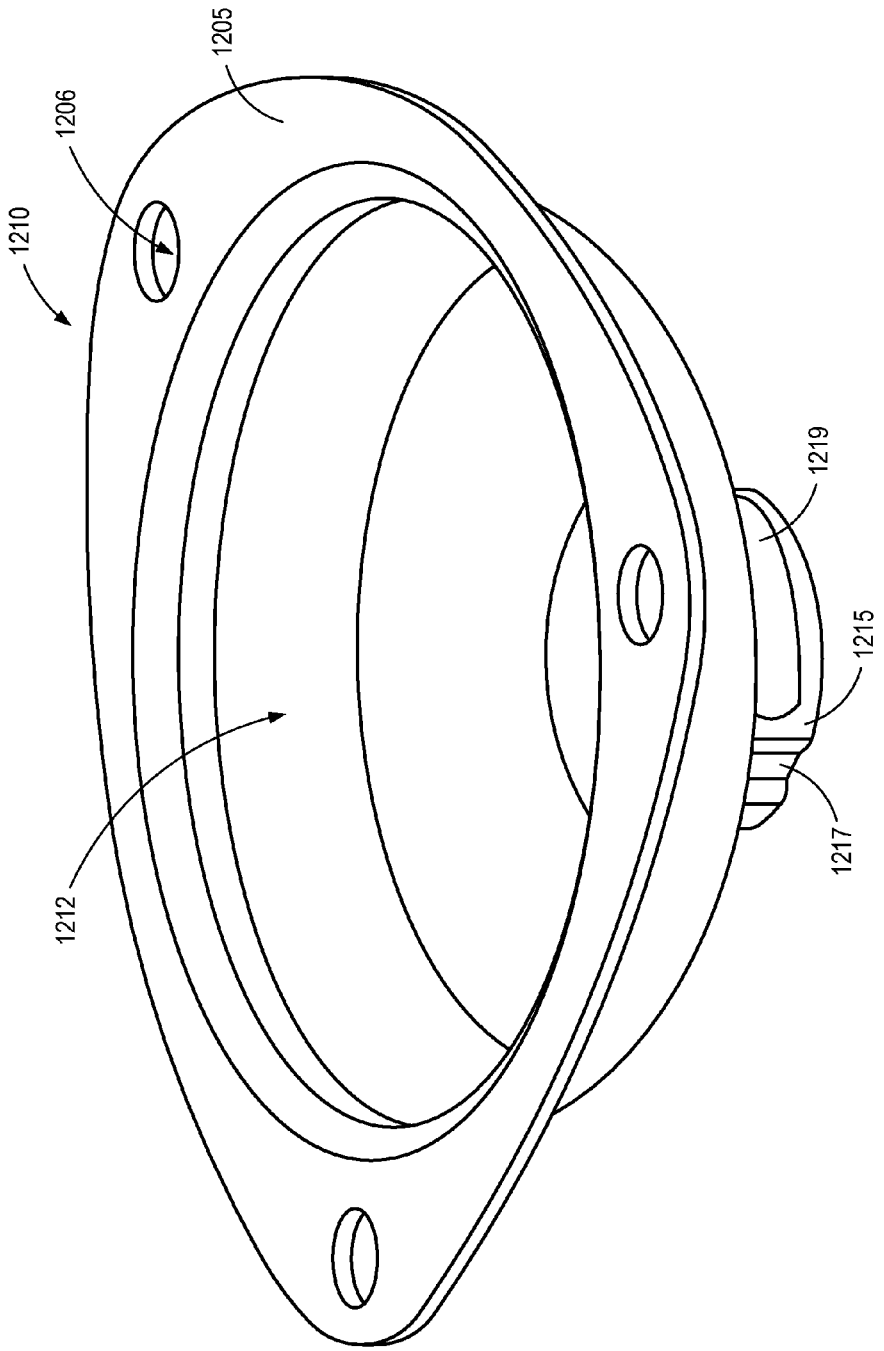

FIG. 12

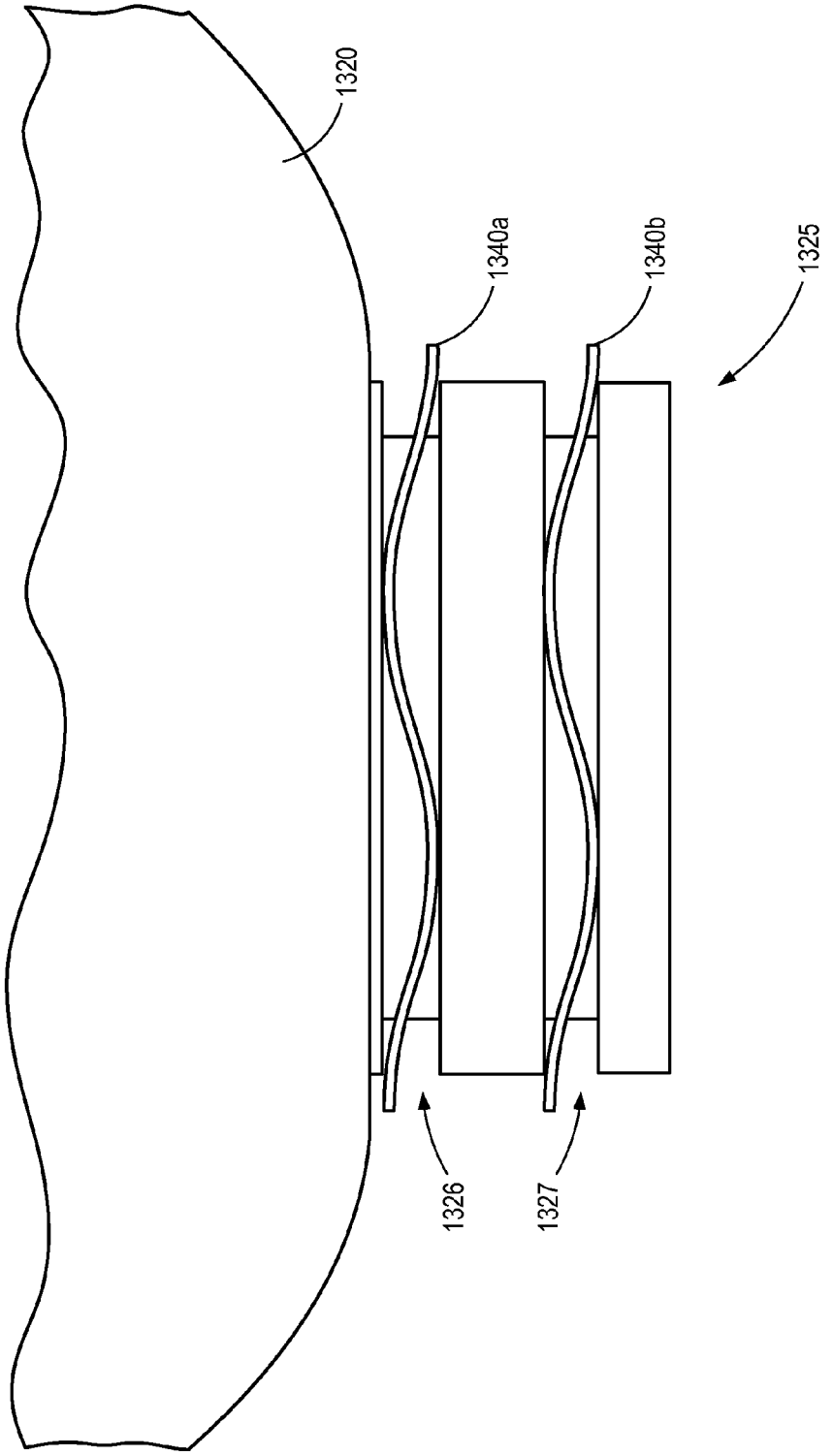

FIG. 13

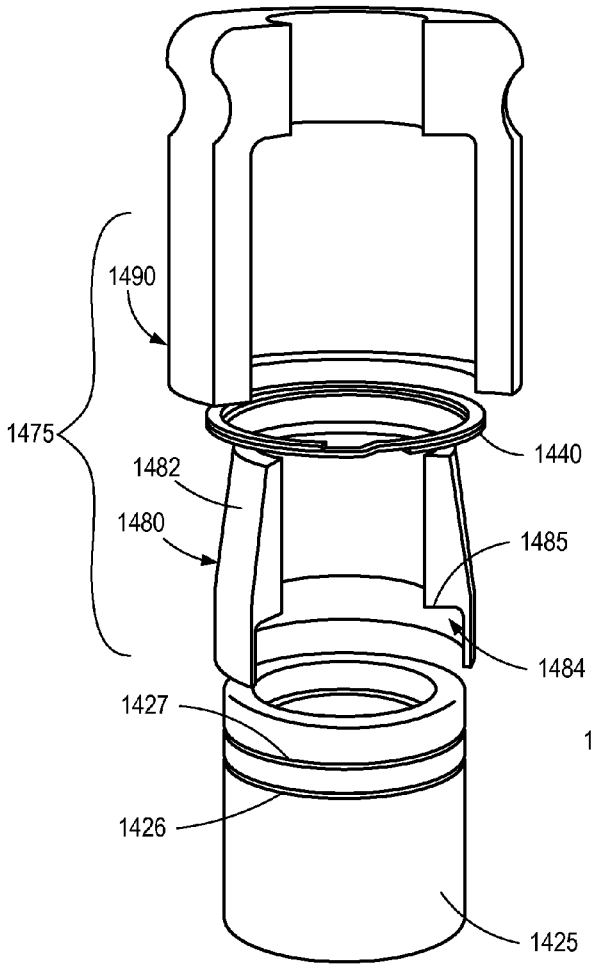

FIG. 14A

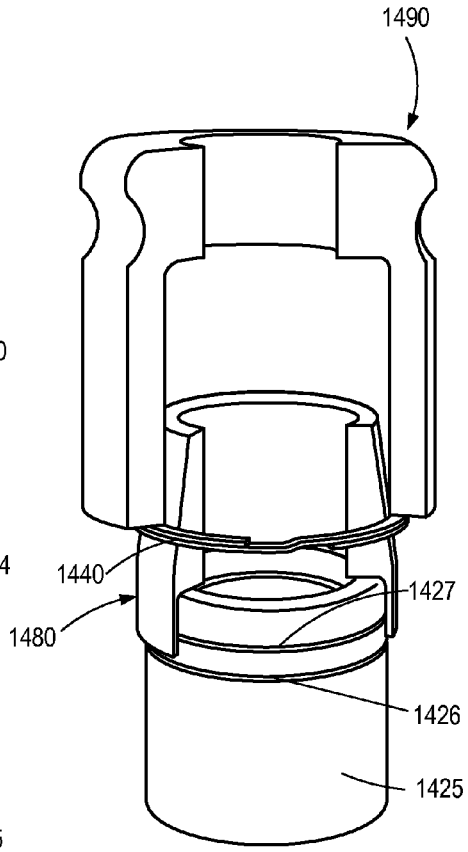

FIG. 14B

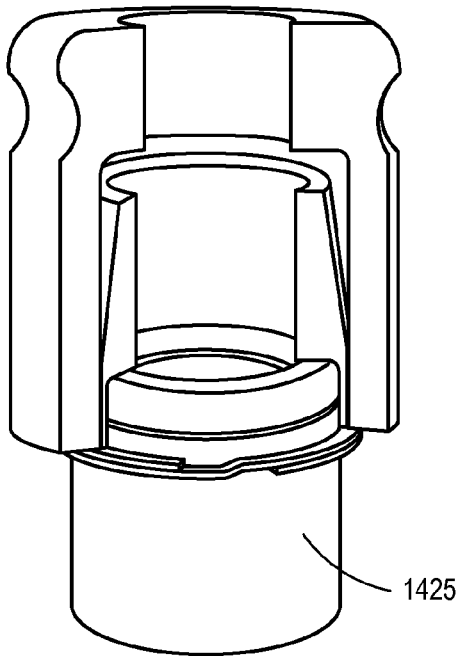

FIG. 14C

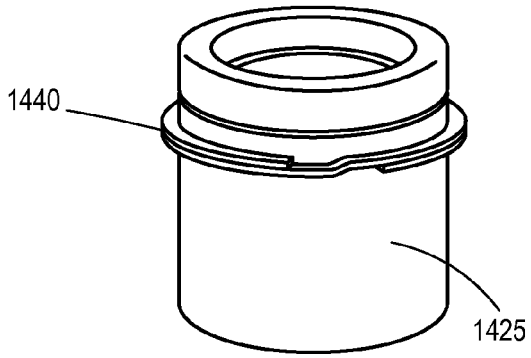

FIG. 14D

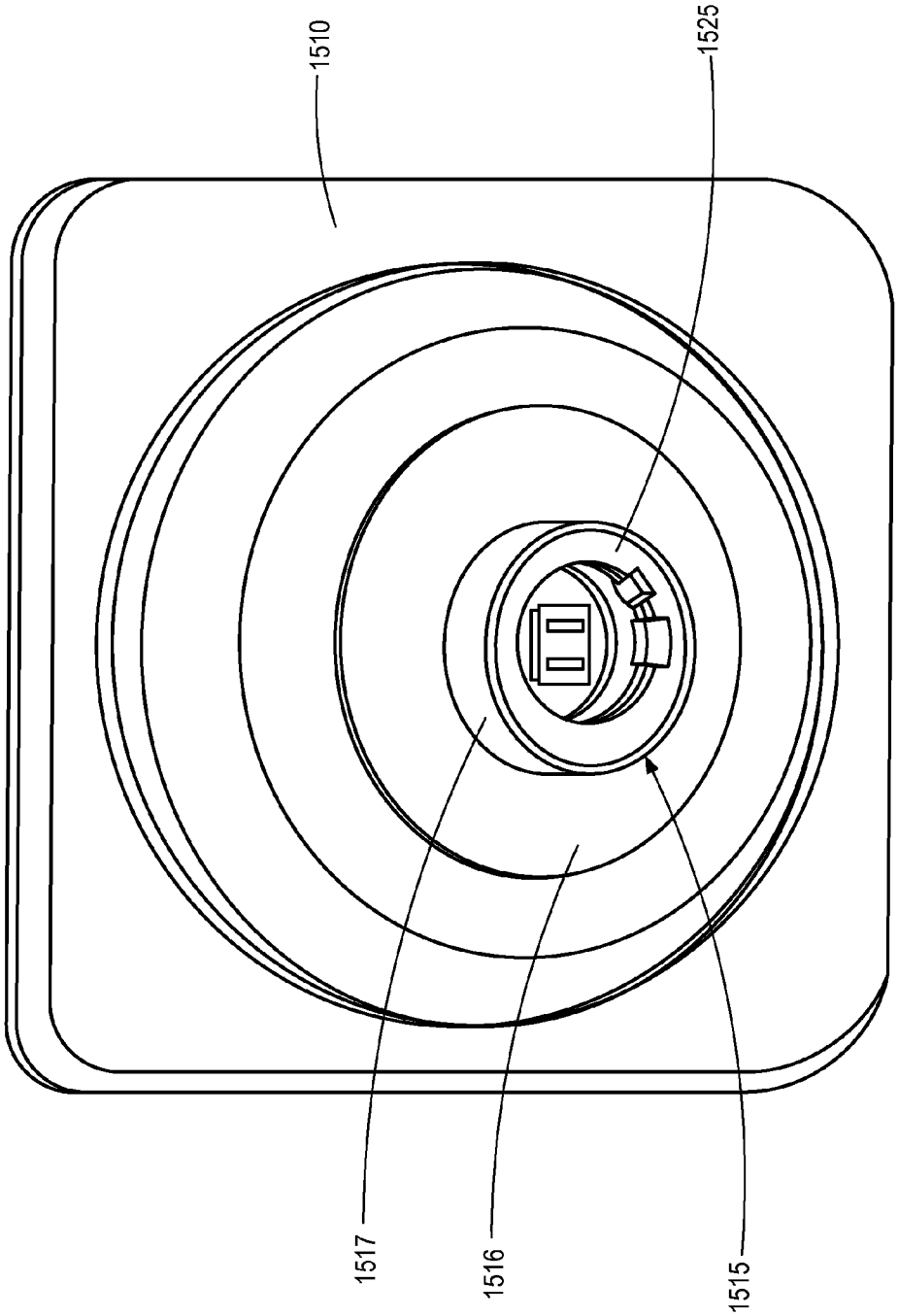

FIG. 15

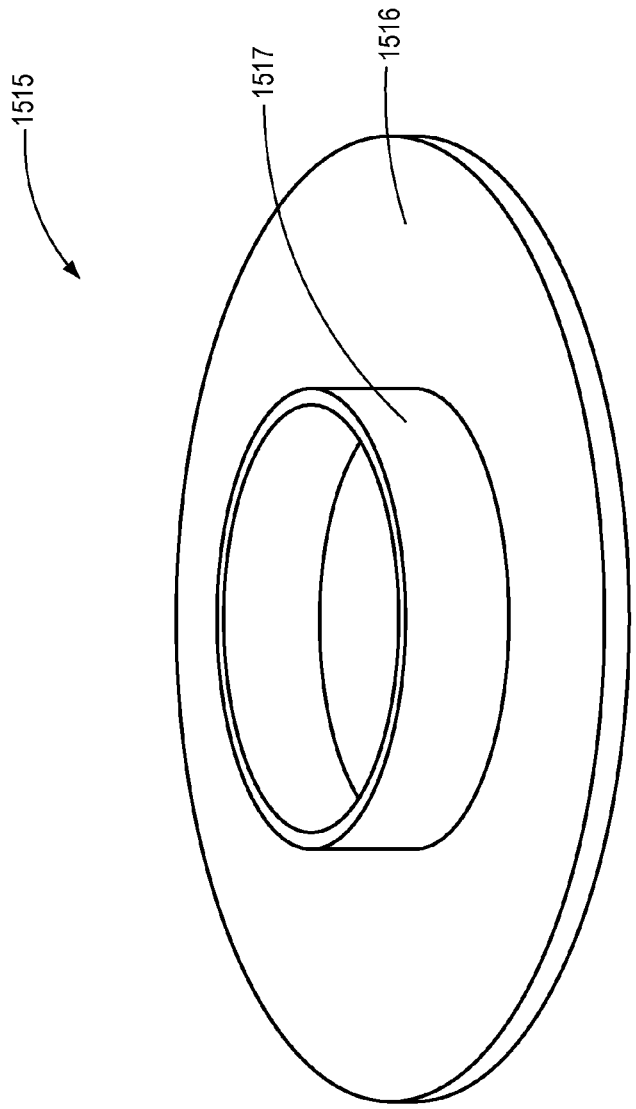

FIG. 16

AIRBAG INFLATOR MOUNTING APPARATUS, METHODS, AND SYSTEMS

SUMMARY

Methods, apparatus, and systems are disclosed herein that relate to coupling an airbag inflator with a housing, such as an airbag module housing or an adapter housing configured to be coupled with an airbag module housing and/or another component of a vehicle airbag system. Some embodiments may be particularly suited to coupling an inflator comprising a composite fiber overwrap with such a housing.

In one more particular example of a vehicle airbag assembly according to certain embodiments, the assembly may comprise a housing comprising an opening, and an inflator comprising a collar configured to be received in the opening. The collar may be configured to extend at least partially through the opening such that at least a portion of the collar extends out of the opening. The assembly may further comprise one or more retainer clips configured to engage the collar to prevent the inflator/inflator collar from being withdrawn from the opening after the collar has been positioned such that at least a portion of the collar extends out of the opening.

In some embodiments, an initiator of the inflator may be at least partially housed within the collar. Some such embodiments may therefore comprise a rigid, strong material, such as steel, carbon winding, aluminum, zinc alloy, Zamak, or another metal, metal alloy, and/or metal composite material.

In some embodiments, the retainer clip may comprise at least two legs. The collar may comprise at least one slot configured to receive at least a portion of at least one of the legs. In some such embodiments, the collar may comprise two opposing slots configured to receive two opposing legs of the retainer clip to prevent the collar from being withdrawn from the opening. The retainer clip(s) may be configured to resiliently bias the collar with respect to the housing to prevent the collar from being withdrawn from the opening. In order to accomplish such resilient biasing, the retainer clip may comprise an offset portion configured to contact a portion of the housing adjacent to the opening when the retainer clip is engaged with the collar such that at least a portion of the retainer clip adjacent to the offset portion is spaced apart from a portion of the housing adjacent to the opening when the retainer clip is engaged with the collar.

In some embodiments, the collar may comprise a projection, and the opening of the housing may comprise a notch configured to receive the projection to align the collar within the opening in a preconfigured rotational position.

In another example of a vehicle airbag assembly according to certain embodiments, the assembly may comprise a housing comprising an opening at least partially defined by a collar sleeve, and an inflator comprising an inflator collar configured to be received in the opening and to extend into the collar sleeve. The inflator collar may comprise at least one crimping feature, such as a crimp groove, configured to facilitate fixed engagement between the inflator collar and the collar sleeve. The crimp groove may be configured to engage a crimp formed in the collar sleeve.

In some embodiments, the collar sleeve may further comprise one or more poka yoke features, such as a flattened portion, protrusion, recession, or the like. In some such embodiments, the inflator collar may comprise a corresponding poka yoke feature configured to facilitate engagement of the inflator collar within the collar sleeve in a preconfigured rotational position. Preferably, the two poka yoke features have complementary shapes to facilitate such engagement.

In some embodiments, the housing may be configured such that, upon engagement of the inflator with the housing, one or more air gaps are formed between the inflator and the housing. For example, in some embodiments, the housing may comprise a plurality of ribs formed within an inner surface of the housing configured to contact the inflator such that a plurality of air gaps are formed between the inflator and the housing in between the ribs.

In some preferred embodiments, the inflator may be configured to be coupled with the housing without requiring rotation of the inflator and/or inflator collar with respect to the housing.

In an example of a method for assembling a vehicle airbag assembly according to some implementations, a housing may be provided comprising an opening. In some implementations, the housing may comprise an airbag module housing. Alternatively, the housing may comprise an adapter housing configured to facilitate coupling of a flangeless inflator to an airbag module housing.

An inflator comprising a collar may be provided. The collar may be positioned into the opening of the housing such that at least a portion of the exterior surface of the collar is adjacent to a portion of the housing defining the opening. The inflator may then be coupled to the housing by engaging an exterior surface of the collar with at least one engagement structure, such as a retainer clip or a crimp formed in a collar sleeve of the housing. In implementations in which the engagement structure comprises a retainer clip, the step of coupling the inflator with the housing may comprise engaging the retainer clip with the collar to prevent the collar from being withdrawn from the opening in the housing. In some preferred implementations, the inflator may then be coupled to the housing without rotating the inflator and/or inflator collar with respect to the housing.

In some implementations, the collar may comprise at least one collar engagement structure, such as a crimp groove. In some such implementations, the step of coupling the inflator with the housing may comprise engaging the at least one collar engagement structure with the at least one engagement structure. In some implementations, the opening of the housing may be at least partially defined by a collar sleeve configured to receive the collar of the inflator. In some such implementations, the step of coupling the inflator with the housing may comprise forming a crimp in the collar sleeve to engage the collar.

The features, structures, steps, or characteristics disclosed herein in connection with one embodiment may be combined in any suitable manner in one or more alternative embodiments and/or implementations.

BRIEF DESCRIPTION OF THE DRAWINGS

Non-limiting and non-exhaustive embodiments of the disclosure are described, including various embodiments of the disclosure with reference to the figures, in which:

FIG. **1** depicts an exploded view of an airbag assembly for a vehicle according to one embodiment.

FIG. **2** depicts the airbag assembly of FIG. **1** in a fully-assembled configuration.

FIG. **3** depicts a plan view of the interface between an inflator collar and a housing for an airbag assembly according to one embodiment.

FIG. **4** is a side elevation view of the embodiment depicted in FIG. **3**.

FIG. **5** is a cross-sectional view of an airbag assembly for a vehicle according to another embodiment.

FIG. **6** is a perspective view of an alternative embodiment of a retainer clip for an inflator.

FIG. **7** is a perspective view of another alternative embodiment of a retainer clip for an inflator.

FIG. **8** is a perspective view of a bottom portion of an inflator comprising a collar according to yet another embodiment.

FIG. **9** depicts a bottom portion of the inflator of FIG. **8** positioned in an embodiment of an adapter housing configured to facilitate coupling of a flangeless inflator to an airbag module housing.

FIG. **10** is a perspective view of the adapter housing of FIG. **9** shown with the inflator removed.

FIG. **11** is a cross-sectional view of the adapter housing and inflator shown in FIG. **9**.

FIG. **12** is a perspective view of an adapter housing configured to facilitate coupling of a flangeless inflator to an airbag module housing according to yet another embodiment.

FIG. **13** illustrates another embodiment of an airbag assembly comprising a collar comprising two grooves and two locking rings.

FIGS. **14**A-**14**D illustrate a tool for coupling locking rings with a slotted collar and various steps used during a process for using such a tool.

FIG. **15** depicts yet another embodiment of an airbag assembly comprising a cap configured to facilitate engagement between an inflator collar and an airbag module housing.

FIG. **16** is a perspective view of the cap of FIG. **15**.

DETAILED DESCRIPTION

A detailed description of apparatus, systems, and methods consistent with various embodiments of the present disclosure is provided below. While several embodiments are described, it should be understood that the disclosure is not limited to any of the specific embodiments disclosed, but instead encompasses numerous alternatives, modifications, and equivalents. In addition, while numerous specific details are set forth in the following description in order to provide a thorough understanding of the embodiments disclosed herein, some embodiments can be practiced without some or all of these details. Moreover, for the purpose of clarity, certain technical material that is known in the related art has not been described in detail in order to avoid unnecessarily obscuring the disclosure.

The embodiments of the disclosure will be best understood by reference to the drawings, wherein like parts may be designated by like numerals. It will be readily understood that the components of the disclosed embodiments, as generally described and illustrated in the figures herein, could be arranged and designed in a wide variety of different configurations. Thus, the following detailed description of the embodiments of the apparatus and methods of the disclosure is not intended to limit the scope of the disclosure, as claimed, but is merely representative of possible embodiments of the disclosure. In addition, the steps of a method do not necessarily need to be executed in any specific order, or even sequentially, nor need the steps be executed only once, unless otherwise specified.

Embodiments of the systems, apparatus, and methods disclosed herein relate to coupling an airbag inflator with an airbag module housing, an adapter configured to be coupled with an airbag module housing, and/or another component of a vehicle airbag system. In some embodiments, various techniques and/or structures are disclosed that may be used to facilitate coupling an inflator comprising a hub or collar with an airbag module housing, an adapter configured to be coupled with an airbag module housing, and/or another component of a vehicle airbag system. In some preferred embodiments, the inflator may comprise an inflator comprising a composite fiber overwrap. Such inflators are disclosed, for example, in U.S. Pat. No. 8,297,653 titled "Pyrotechnic Inflator with Composite Overwrap," the entire contents of which are hereby incorporated by reference herein. However, it should be understood that the concepts disclosed herein may be applicable to a wide variety of other inflators, such as other flangeless inflators and/or other inflators lacking certain mounting features and/or components.

Additional details of certain embodiments and implementations will now be discussed in greater detail in connection with the accompanying figures. FIG. **1** depicts an embodiment of a vehicle airbag assembly **100**. Vehicle airbag assembly **100** comprises a housing **110** comprising an opening **115**. Housing **110** comprises an airbag module housing **110**. However, other embodiments are contemplated in which the housing may instead comprise an adapter configured for coupling to an airbag module housing, as discussed in greater detail below.

Opening **115** is positioned on a recess **112** of housing **110**. Recess **112** comprises a hemispherical shape that, as depicted in FIG. **1**, at least substantially matches a shape of an inflator **120** that may also be part of airbag assembly **100**. Recess **112**, as also depicted in FIG. **1**, protrudes from an exterior surface of housing **110**. Of course, a wide variety of alternative embodiments are contemplated. For example, some embodiments may comprise a recess comprising a different shape, some embodiments may comprise a recess that does not protrude from an exterior surface of the housing, and some embodiments may lack such a recess entirely.

Inflator **120** comprises a collar **125** configured to be received in the opening **115**. More particularly, collar **125** is configured to extend at least partially through the opening **115** such that at least a portion of the collar **125** extends out of opening **115** when airbag assembly **100** is fully assembled. In some embodiments, collar **125** may comprise a metal collar. In some embodiments, collar **125** may be configured to at least partially house an initiator within the collar **125**. In some such embodiments, collar **125** may fully house an initiator therein.

Vehicle airbag assembly **100** further comprises an airbag cushion **130**, which may be positioned within housing **110**. Inflator **120** may be positioned within airbag cushion **130**. As shown in FIG. **1**, airbag cushion **130** may comprise an opening **135** that may be aligned with opening **115** in housing **110** such that collar **125** may extend through both opening **115** and opening **135** in an assembled configuration.

Vehicle airbag assembly **100** further comprises a retainer clip **140**. Retainer clip **140** may be configured to engage collar **125** to prevent collar **125** from being withdrawn from opening **115** after collar **125** has been positioned such that at least a portion of the collar **125** extends out of opening **115**. Retainer clip **140** may be coupled to collar **125** by way of one or more slots **126** formed within an exterior surface of collar **125**. In some embodiments, collar **125** may comprise two opposing slots configured to receive two opposing legs, such as legs **142** and **144** of retainer clip **140**, to prevent collar **125** from being withdrawn from opening **115**. At least a portion of one or more of the retainer clip legs may be configured to engage a portion of the housing, such as housing **110**, adjacent to the opening, such as opening **115**, through which the collar, such as collar **125**, extends.

FIG. **2** depicts airbag assembly **100** in a fully-assembled configuration. More particularly, inflator collar **125** has been

extended through opening **115** and legs **142** and **144** of retainer clip **140** have been engaged with opposing slots **126** (only one slot is visible in the figure) of collar **125**.

FIG. **3** depicts an interface between an inflator collar **325**, a retainer clip **340**, and a housing **310** according to another embodiment of a vehicle airbag assembly. As shown in this figure, retainer clip **340** comprises three legs, namely, legs **342**, **343**, and **344**. Legs **342** and **344** extend along opposite ends of retainer clip **340** and leg **343** is positioned therebetween. It can also be seen in FIG. **3** that leg **343** is shorter and wider than legs **342** and **344**. Leg **343** may be configured to be at least partially received in a third slot in collar **325** (not directly visible in the figure). The dimensions of the various portions of retainer clip **340** may vary as desired in accordance with particular applications.

The collar **325** of the embodiment depicted in FIG. **3** also comprises a projection **326**. Projection **326** may be configured to be received within a corresponding notch **316** formed within opening **315**. Notch **316** may be configured to receive projection **326** in order to align collar **325** within opening **315** in a preconfigured rotational configuration. In some embodiments, the notch may instead be formed within the collar and the projection may be formed in the opening in the housing that receives the collar. In some embodiments, a plurality of such notch/projection combinations may be provided.

FIG. **3** also illustrates that collar **325** at least partially encloses an initiator **328** of an inflator. It may therefore be desirable to form collar **325** from a rigid, protective material, such as a metal or metal composite material.

In some embodiments, the retainer clip(s) may be configured to resiliently bias an inflator collar with respect to a housing, such as an airbag module housing, to prevent the collar from being withdrawn from an opening in the housing. For example, as shown in FIG. **4**, retainer clip **340** further comprises a first offset portion **344***a* and a second offset portion **344***b*, both of which are configured to contact a portion of the housing **310** adjacent to opening **315** when the retainer clip **340** is engaged with collar **325**. In the depicted embodiment, a portion of retainer clip **340** in between the two offset portions **344***a* and **344***b* is spaced apart from a portion of the housing **310** adjacent to opening **315** when the retainer clip **340** is engaged with collar **325**. This may allow for retainer clip **340** to act as a leaf spring or other resiliently biasing member by providing room for retainer clip **340** to flex while in contact with housing **310**. Although not as clearly visible in FIG. **4**, it is contemplated that some embodiments may similarly comprise offset portions on leg **342** as well.

FIG. **5** illustrates another embodiment of a vehicle airbag assembly **500**. Airbag assembly **500** comprises a housing **510** comprising an opening **515**. Housing **510** comprises an airbag module housing. However, in other embodiments, housing **510** may alternatively comprise an adapter configured for coupling inflator **520** to an airbag module housing.

Inflator **520** comprises a collar **525** that is received in the opening **515**. More particularly, collar **525** extends through opening **515** such that at least a portion of collar **525** extends out of opening **515** in the assembled configuration depicted in FIG. **5**. In some embodiments, collar **525** may comprise a metal material, such as steel. In the depicted embodiment, collar **525** comprises a sleeve **529** configured to facilitate coupling of collar **525** to inflator **520**. Sleeve **529** may be engaged under the body, or another portion of, inflator **520**. This may be useful for embodiments in which one or more portions of the inflator are made of another material, such as a thermoplastic material. By providing a separate collar that may be coupled with another part of inflator **520**, such as a main body of inflator **520**, the weight and/or cost of inflator **520**, and therefore the weight and/or cost of the airbag assembly **500**, may be reduced. In addition, plastic may not be strong enough to withstand airbag deployment loads for a configuration in which the cushion loads are anchored into the inflator collar. Thus, it may be desirable for certain embodiments to provide a steel or other stronger structural piece that is separately coupled to the inflator. However, other embodiments are contemplated in which collar **525** may be an integral part of inflator **520**.

Vehicle airbag assembly **500** further comprises a hook **512** positioned on an exterior surface of housing **510**. Hook **512** may be used to receive a flap **532** of airbag cushion **530**, which may be useful to orient the airbag cushion **530** and/or other components of vehicle airbag assembly **500** in a desired position, such as a desired rotational configuration, with respect to other components of airbag assembly **500**. In some embodiments, flap **532** may comprise a corresponding hook or other similar structure configured to engage hook **512**.

It can also be seen in FIG. **5** that collar **525** at least partially encloses an initiator **528** of inflator **520**. It may therefore be desirable to form collar **525** from a rigid, protective material, such as a metal or metal composite material.

Inflator **520** may further comprise an overwrap **521** formed about at least a portion of a subassembly of the inflator **520**. Overwrap **521** may be provided in order to facilitate withstanding the high pressures generated within a combustion chamber of inflator **520** upon reaction of the pyrotechnic material contained therein. In some embodiments, overwrap **521** may comprise a composite of fibers comprising at least one of glass, basalt, and a resin matrix system.

Inflator **520** may further comprise a shell member **522** and an end cap **523**. In some embodiments, the shell member **522** may comprise an open end, which may permit access to an interior of shell member **522**, and a closed end positioned at least substantially opposite from the open end.

In some embodiments, shell member **522** may comprise a generally elliptical, truncated bulbous, or rounded disc form or shape. Those of ordinary skill in the art, however, will, using the teachings provided herein, appreciate that shell members of other forms or shapes can, if desired, be used. For example, some embodiments may comprise a spherical shell member. While spherical shell members can be advantageous from a structural design point of view, such shell members may, for certain applications, hinder installation and placement of an inflator assembly in a vehicle. Flat, closed end shell members may also be used for certain embodiments. However, such embodiments may not be sufficiently strong as may be desirable for certain applications. Thus, the use of an at least substantially elliptical-shaped shell member may be preferred for certain applications, as it may provide sufficient strength in structural design while also reducing the height of the resulting inflator assembly.

In some embodiments, shell member **522** may comprise a metal, such as drawn steel or aluminum, for example. Shell member **522** may comprise a thickness that is less than conventional pyrotechnic pressure vessel housings. For example, whereas conventional pyrotechnic pressure vessel metal housings are commonly 2 to 3 mm thick, by providing overwrap **521**, metal shell members **522** having a thickness of less than 1 mm, and in some cases less than 0.5 mm, may be used. In alternative embodiments, shell member **522** may instead, or additionally, comprise a plastic material. In some embodiments, shell member **522** may be incapable of withstanding the pressure generated within the combustion chamber of inflator **520** upon reaction of the pyrotechnic material contained therein without the support provided by overwrap **521**.

In some embodiments, the end cap **523** may comprise a molded plastic with at least a portion of initiator **528** integrally molded therein. For example, in some embodiments, a glass-filled nylon, such as 33% glass-filled nylon 6/12, may be used. One or more metal inserts may be included to improve the structural capability of the end cap **523** if desired. In other embodiments, end cap **523** may comprise a cast or machined metal, such as aluminum, with the initiator **528** crimped or molded in position therein.

In some embodiments, shell member **522** and end cap **523** may be joined together by crimping shell member **522** over end cap **523**. In other embodiments, end cap **523** and/or shell member **522** may be formed of molded plastic. In some such embodiments, shell member **522** and end cap **523** may be snapped together. Similarly, in some embodiments, collar **525** may be coupled with end cap **523** by molding or otherwise inserting sleeve **529** into end cap **523**. Alternatively, collar **525** may be engaged under a portion of inflator **520**, such as by inserting sleeve **529** underneath shell member **522**.

FIG. **5** also depicts retainer clip **540** positioned within collar **525** adjacent to opening **515** of housing **510**. As mentioned above, retainer clip **540** may be configured such that, when positioned in a fully-assembled configuration, as shown in FIG. **5**, retainer clip **540** may comprise one or more portions that are in contact with a portion of housing **510** around opening **515** and one or more portions that are spaced apart from housing **510**. In this manner, retainer clip **540** may be allowed to flex and may resiliently bias collar **525**, and thereby resiliently bias inflator **520**, towards a seated position with respect to housing **510**.

FIGS. **6** and **7** depict alternative embodiments of retainer clips, namely retainer clips **640** and **740**, respectively. Both retainer clip **640** and retainer clip **740** comprise two legs. Thus, retainer clip **640** comprises legs **642** and **644**, whereas retainer clip **740** comprises legs **742** and **744**. Each leg of each retainer clip depicted in these figures further comprises two offset portions configured to allow the respective retainer clips to resiliently bias a collar of an inflator towards a housing. More particularly, leg **642** of retainer clip **640** comprises a first offset portion **642***a* and a second offset portion **642***b*. This allows for a portion of leg **642** in between offset portions **642***a* and **642***b* to be spaced apart from a portion of a housing adjacent to an inflator collar in a fully-assembled configuration. Similarly, leg **644** of retainer clip **640** comprises a first offset portion **644***a* and a second offset portion **644***b*. Legs **642** and **644** of retainer clip **640** comprise a circular cross-sectional shape.

Retainer clip **740**, by contrast, comprises legs **742** and **744** that comprise a rectangular cross-sectional shape. This type of cross-sectional shape may be preferable for certain embodiments, such as, for example, embodiments comprising an inflator collar having a slot having one or more flat surfaces configured to engage a corresponding flat surface of a retainer clip leg. However, like retainer clip **640**, legs **742** and **744** of retainer clip **740** both comprise two offset portions at opposite ends of these legs. More particularly, leg **742** comprises offset portions **742***a* and **742***b*, whereas leg **744** comprises offset portions **744***a* and **744***b*.

As depicted in FIG. **6** and FIG. **7**, in some embodiments, offset portions **642***a*, **644***a*, **742***a*, and **744***a* may also, or alternatively, comprise widened portions such that the opening defined by the opposing legs widens at offset portions **642***a*, **644***a*, **742***a*, and **744***a*. In other embodiments, a retainer clip comprising a c-clip or another similar clip available to those of ordinary skill in the art may be used.

FIG. **8** is a perspective view depicting a lower portion of an alternative embodiment of an inflator **820** comprising an inflator collar **825**. Inflator collar **825** is configured to be received in an opening of a housing—such as an airbag module housing or an adapter housing configured to facilitate coupling of a flangeless inflator to an airbag module housing. In some embodiments, collar **825** may be configured to extend into a collar sleeve of a housing, as discussed below. Collar **825** further comprises a crimping feature **826** configured to facilitate fixed engagement between the collar **825** and a collar sleeve of a housing. In the depicted embodiment, crimping feature **826** comprises a crimp groove **826**. Crimp groove **826** may be configured to engage a crimp formed in a collar sleeve of a housing, as shown in, and described in greater detail with respect to, FIG. **9**. Crimp groove **826** is an example of a crimping feature configured to engage a crimp formed in a collar sleeve of a housing.

Collar **825** further comprises a poka yoke feature **827**. Poka yoke feature **827** may be configured to engage a corresponding poka yoke feature formed in a collar sleeve of a housing. For example, as illustrated in FIG. **9**, poka yoke feature **827** engages poka yoke feature **817** of collar sleeve **815** of housing **810**. Engagement of poka yoke features **817** and **827** may facilitate engagement of inflator collar **825** within collar sleeve **815** of housing **810** in a preconfigured rotational position. Poka yoke features **817** and **827** may comprise, for example, matching projections/recessions, matching flattened surfaces, matching rounded surfaces that differ from a radius of curvature of the inflator collar, and the like. The poka yoke features disclosed herein may be used for error proofing for installation and/or may be used for desired component orientation.

As also depicted in FIG. **9**, collar sleeve **815** has been coupled with collar **825** by crimping collar sleeve **815** to collar **825**. More particularly, collar sleeve **815** comprises a crimp **819** formed on an external surface of collar sleeve **815** that engages crimp groove **826** (not visible in FIG. **9**) formed in an external surface of collar **825**. Depending upon the materials used to form collar **825** and collar sleeve **815**, crimp **819** may be pre-formed in collar sleeve **815**, or may be formed in collar sleeve **815** after collar **825** has been inserted into collar sleeve **815**. Preferably, however, for embodiments in which collar **825** comprises a rigid metal material, crimp groove **826** is pre-formed in collar **825** to facilitate formation of crimp **819** and engagement between crimp **819** and collar **825**.

Crimp **819**, as well as each of the retainer clips disclosed herein, are examples of engagement structures for fixedly coupling an inflator with a housing by engaging an exterior surface of an inflator collar with the engagement structure. Similarly, crimp groove **826** is an example of a collar engagement structure configured for engaging an engagement structure in order to fixedly couple an inflator collar with a housing.

In the embodiment depicted in FIG. **9**, housing **810** comprises an adapter housing configured to facilitate coupling of inflator **825** with an airbag module housing, such as airbag module housing **100** depicted in FIG. **1**. However, it is contemplated that, in alternative embodiments, one or more of the features, elements, principles, or components depicted in FIG. **9** may be applied to couple an inflator directly to an airbag module housing comprising an airbag cushion. In other words, housing **810** may alternatively comprise an airbag module housing. However, because housing **810** comprises an adapter housing, housing **810** further comprises a plurality of openings **806** formed in a base or flange **805** of housing **810** to facilitate coupling of housing **810** with an airbag module housing or another component of such a mod-

ule. Openings **806** may be configured to each receive a fastener **808**, such as a clinch stud, therein.

FIG. **10** depicts adapter housing **810** apart from inflator **820**. As shown in this figure, housing **810** comprises a recess **812** that may be configured to receive an inflator, such as inflator **820**, therein. Recess **812** comprises a hemispherical shape that may at least substantially match a shape of a bottom portion of an inflator. Of course, as mentioned above, other embodiments are contemplated in which the shape of recess **812** and/or the shape of the corresponding inflator may differ as desired.

Recess **812** further comprises a plurality of ribs **813**. Ribs **813** may be used to create one or more air gaps **814**, as shown in FIG. **11**, in between inflator **820** and housing **810** when inflator **820** has been coupled with housing **810**. Air gaps **814** may be useful to facilitate desirable thermal dissipation with respect to heat generating during deployment of inflator **820**. In some embodiments, certain heat-dissipating materials, coolants, gels, or other such materials may be inserted within one or more of the air gaps **814**. Also, although in the embodiment depicted in FIGS. **10** and **11** the ribs **813** are relatively thin and therefore the majority of the surface area of the interface between the inflator **820** and recess **812** of the housing **810** comprises the air gaps **814**, other embodiments are contemplated in which the ribs **813** are wider and therefore may occupy a greater, and in some embodiments a majority, of the surface area of this interface.

FIG. **12** depicts an alternative embodiment of an adapter housing **1210** comprising a flange **1205** configured to facilitate coupling of housing **1210** with an airbag module housing or another component of an airbag assembly. Openings **1206** are formed within flange **1205** that are configured to each receive a fastener (not shown in the figure), such as a clinch stud, therein. Unlike adapter housing **810**, which comprises a rectangular flange **805** and a fastener opening **806** positioned at each corner of the rectangular flange **805**, adapter housing **1210** comprises a triangular flange **1205** comprising a fastener opening **1206** positioned at each of the three corners of flange **1205**.

As shown in FIG. **12**, housing **1210** further comprises a recess **1212** that may be configured to receive an inflator (not shown in the figure) therein. Recess **1212** may therefore comprise a shape that at least substantially matches with a corresponding shape of a portion of the inflator. Although, unlike housing **810**, recess **1212** of housing **1210** lacks ribs for creating one or more air gaps after assembly with an inflator, other embodiments are contemplated in which such ribs may be present.

Housing **1210** also comprises a collar sleeve **1215** comprising a poka yoke feature **1217** comprising a flattened surface that may be used to orient an inflator collar in a preconfigured rotational position within collar sleeve **1215**. In addition, collar sleeve **1215** comprises a crimp **1219** formed on an external surface of collar sleeve **1215** that may be coupled with a corresponding crimp groove formed in an external surface of an inflator collar, as described above. As also mentioned above, crimp **1219** may be pre-formed in collar sleeve **1215**, as depicted in FIG. **12**, or, alternatively, may be formed in collar sleeve **1215** during assembly after an inflator collar has been inserted into collar sleeve **1215**.

In an example of a method for assembling a vehicle airbag assembly according to some implementations, a housing may be provided comprising an opening. In some implementations, the housing may comprise an airbag module housing. Alternatively, the housing may comprise an adapter housing configured to facilitate coupling of a flangeless inflator to an airbag module housing.

An inflator comprising a collar may be provided. The collar may be positioned into the opening of the housing such that at least a portion of the exterior surface of the collar is adjacent to a portion of the housing defining the opening. The inflator may then be fixedly coupled to the housing by engaging an exterior surface of the collar with at least one engagement structure, such as a retainer clip or a crimp formed in a collar sleeve of the housing. In implementations in which the engagement structure comprises a retainer clip, the step of fixedly coupling the inflator with the housing may comprise engaging the retainer clip with the collar to prevent the collar from being withdrawn from the opening in the housing. In some preferred implementations, the inflator may then be fixedly coupled to the housing without rotating the inflator and/or inflator collar with respect to the housing.

In some implementations, the collar may comprise at least one collar engagement structure, such as a crimp groove. In some such implementations, the step of fixedly coupling the inflator with the housing may comprise engaging the at least one collar engagement structure with the at least one engagement structure. In some implementations, the opening of the housing may be at least partially defined by a collar sleeve configured to receive the collar of the inflator. In some such implementations, the step of fixedly coupling the inflator with the housing may comprise forming a crimp in the collar sleeve to engage the collar.

FIG. **13** illustrates another embodiment of an airbag assembly comprising a collar and two locking rings. This figure depicts inflator **1320** comprising an inflator collar **1325** having a first collar slot or groove **1326** and a second collar slot **1327**. Collar slots **1326** and **1327** are configured to receive engagement structures **1340***a* and **1340***b*, respectively. Engagement structures **1340***a* and **1340***b* both comprise locking rings.

Locking rings **1340***a* and **1340***b* comprise waved or curved locking rings. Waved retaining rings may be preferable for certain applications since they may provide shock absorption to an airbag module. Thus, the size of the slot(s) within which the locking ring(s) sit may be larger than a compressed size of the locking ring(s), and may be adjusted based upon desired dampening characteristics. However, alternative embodiments are contemplated in which one or both of the locking rings comprise flat rings. Similarly, although collar **1325** is depicted with two slots, alternative embodiments may comprise only a single slot and, thus, only a single locking ring.

In some embodiments, metal or plastic housings may be used to seat the locking ring(s). The size of the slots on the inflator collar may also be enlarged for larger load carrying capacity. Similarly, one or more dimensions of the locking ring(s) (flat or waved) may be adjusted to distribute the load over a desired area of the housing.

In some embodiments, the ring(s) may define a closed ring. Alternatively, the ring(s) may comprise a split ring(s). In some embodiments, the ring(s) may have multiple layers, which may add to shock-absorbing functionality. In some embodiments, the ring(s) may also be made tamper proof.

In some embodiments, the ring(s) may comprise an orientation feature, such as poka yoke feature **827** of collar **825**, which may be used to facilitate coupling of the inflator to a housing at a desired orientation. Such rings may, for example, be configured to lock into a keyway in the slot in the inflator collar. In some embodiments, a similar or identical keyway may also, or alternatively, be formed in the housing to allow for locking/selected orientation of the collar, ring, and/or inflator with respect to the housing as well.

Locking rings **1340***a* and **1340***b* may be configured to engage opposite sides and/or surfaces of a housing, such as an

airbag module housing to facilitate fixedly coupling inflator **1320** with the housing. More particularly, locking rings **1340***a* and **1340***b* both extend beyond the perimeter of the portions of collar **1325** that are adjacent to slots **1326** and **1327**, thereby allowing for engagement between, for example, two opposing sides of an opening of a housing, or two separate structures positioned adjacent to collar **1325**.

In some embodiments, and some implementations of manufacturing methods, the inflator may be manufactured with the first ring (flat or waved) in place at the time of inflator assembly or as a post inflator assembly operation. In some such embodiments and implementations, the first ring may be pre-installed prior to assembly of a module housing with the inflator.

For example, in some embodiments and implementations, locking ring **1340***a* may be positioned within slot **1326** at the time of assembly of inflator **1320**. As a post operation, the ring(s) may be added at e-check or quality inspection. The ring(s) may be reserved during such processes such that the ring(s) is only installed if the inflator passes quality inspection.

In some embodiments, the first ring may function as a cushion location ring. In other words, the first ring may be shaped such that it mates with or otherwise receives the airbag cushion in a particular manner, such as by providing a mating feature on the cushion, to locate the cushion to a specific depth. For example, ring **1340***a* may, in some embodiments, be configured to be larger and/or have other features and/or components to allow for such functionality.

In some embodiments, and some implementations of manufacturing methods, a second ring, such as ring **1340***b*, may be coupled with a collar, such as inflator collar **1325**, following a step of coupling an inflator and/or collar with a housing. For example, in some embodiments and implementations, inflator collar **1325** may be inserted into an opening in an airbag module housing such that ring **1340***a* abuts a portion of the airbag module housing adjacent to the opening, after which a second locking ring, such as locking ring **1340***b*, may be inserted in slot **1327** to prevent inflator collar **1325** from exiting the housing opening.

In some embodiments and implementations, the locking ring(s) may be the only fastener(s) used to couple the inflator with a housing, which may allow for reducing weight, cost and LMPU. Providing locking ring(s) with sufficient size and/or strength may also allow for distribution of a load over a larger area of the housing, which may allow for elimination of the need for additional load-bearing washer and metal brackets.

FIGS. **14**A-**14**D illustrate a tool for coupling one or more locking rings with a slotted collar and various steps used during a process for using such a tool. More particularly, FIG. **14**A depicts a tool **1475** comprising two parts, namely, an inner sleeve **1480** configured to be partially received in an outer sleeve **1490**. Inner sleeve **1480** comprises an outer surface **1482** that tapers to allow for receipt of a locking ring **1440** over the top of inner sleeve but, due to the tapering, prevents locking ring **1440** from passing all of the way over inner sleeve **1480** without being flexed and/or deformed, as depicted in FIG. **14**B.

Inner sleeve **1480** further comprises a recessed area **1484** defined in part by a ledge **1485**. Ledge **1485** allows inner sleeve **1480** to rest on collar **1425** such that the exterior surface of inner sleeve **1480** blocks one but not both of the locking ring slots. More particularly, as shown in FIG. **14**B, when fully positioned on the end of collar **1425**, inner sleeve **1480** covers slot **1427** but not slot **1426**. As such, outer sleeve **1490** may be used to press locking ring **1440** down over the exterior surface of inner sleeve **1480** and into locking ring slot **1426**, as depicted in FIG. **14**C. Thus, preferably outer sleeve **1490** has an inner diameter that is approximately equal to, or slightly greater than, the exterior diameter of inner sleeve **1480**.

Once the locking ring **1440** has been positioned with the distal slot **1426**, the outer sleeve **1490** and the inner sleeve **1480** may be removed from collar **1425**, as depicted in FIG. **14**D. Collar **1425** may then be coupled with a housing by inserting collar **1425** into a housing opening, as previously described, after which a second installation tool similar to tool **1475** may be used, if desired, to insert a second locking ring within slot **1427** to lock collar **1425** within such opening. In some embodiments, the dimensions of the second installation tool (not shown) may differ so as to facilitate such coupling. For example, the depth of the recessed area of such tool may be less than the depth of recessed area **1484** of tool **1475** such that it does not cover slot **1427**.

FIG. **15** depicts yet another embodiment of an airbag assembly comprising a crimp cap **1515** configured to facilitate engagement between an inflator collar **1525** and an airbag module housing **1510**. Crimp cap **1515** should be considered another example of an engagement structure fixedly coupling an inflator with a housing.

Inflator collar **1525** is configured to be received in an opening of a housing—such as an airbag module housing or an adapter housing configured to facilitate coupling of a flangeless inflator to an airbag module housing. For example, in some embodiments, collar **1525** may be configured to extend into a collar sleeve of a housing, as previously discussed. Collar **1525** may, in some embodiments, further comprise a crimping feature, such as a groove, configured to facilitate fixed engagement between the collar **1525** and crimp cap **1515**. Similarly, in some embodiments, crimp cap **1515** may comprise a similar protrusion or other crimping feature configured to further facilitate such crimping.

FIG. **16** is a perspective view of crimp cap **1515**. Crimp cap **1515** may comprise a collar **1517** that may be configured to fit over collar **1525** and may further comprise a plate or flange **1516** configured to abut a portion of a housing, such as housing **1510**, in order to secure collar **1517** in place relative to housing **1510**. Flange **1516** may be used to distribute the inflator and/or cushion loads across the housing. In some embodiments, plate/flange **1516** may be flat. Alternatively, plate/flange **1516** may comprise a curved surface that may be configured to mate with a corresponding curved surface of a housing.

In some embodiments, collar **1525**, like collar **825** for example, may further comprises a poka yoke feature similar to poka yoke feature **827**. In some embodiments, once crimp cap collar **1517** has been positioned over inflator collar **1525**, a crimping may be applied to rigidly affix collar **1517** to collar **1525**. As previously mentioned, in some embodiments, collar **1525** may comprise a groove configured to facilitate such crimping.

Crimp cap **1515** may be made up of steel and may, in some embodiments, be rounded on the end to go around an inflator initiator and form an open cup. In some embodiments, crimp cap **1515** may be used in conjunction with one or more of the other inventive concepts disclosed herein and/or other known concepts/components. For example, in some embodiments, crimp cap **1515** may be used with a retainer clip, such as retainer clip **140**. In some embodiments, crimp cap **1515** may be used with a bayonette-style adapter on an initiator, may be used with a flange-style adapter on an initiator, and/or may be crimped such that the airbag cushion and inflator are pulled tightly in contact with the housing to reduce BSR and NVH.

Metal may be added to crimp cap **1515** to allow for Module Damping when needed. Crimp cap **1515** may also be formed in a metal housing when the housing is stamped. In some embodiments, stiffening ribs may be added to a recess area defined by plate/flange **1516**, similar to ribs **813**. The crimp cap **1515** may be molded into a housing to reduce the additional component at the module level if desired. The crimp cap **1515** may be crimped into a mating metal part on the inflator's initiator end designed to provide strength and tightening of the inflator to the housing.

In some embodiments, one or more additional locking features may be added to the housing and/or flange if needed. For example, as mentioned above, additional crimps may be added and/or other locking components, such a locking rings and/or retainer clips, may be used to further solidify the engagement between the crimp cap and the housing.

The foregoing specification has been described with reference to various embodiments and implementations. However, one of ordinary skill in the art will appreciate that various modifications and changes can be made without departing from the scope of the present disclosure. For example, various operational steps, as well as components for carrying out operational steps, may be implemented in various ways depending upon the particular application or in consideration of any number of cost functions associated with the operation of the system. Accordingly, any one or more of the steps may be deleted, modified, or combined with other steps. Further, this disclosure is to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope thereof. Likewise, benefits, other advantages, and solutions to problems have been described above with regard to various embodiments. However, benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced, are not to be construed as a critical, a required, or an essential feature or element.

Those having skill in the art will appreciate that many changes may be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, be determined only by the following claims.

The invention claimed is:

1. A method for assembling a vehicle airbag assembly, the method comprising the steps of:

providing a housing comprising an opening;

providing an inflator comprising a collar, wherein the collar comprises an exterior surface;

positioning the collar of the inflator into the opening of the housing such that at least a portion of the exterior surface of the collar is adjacent to a portion of the housing defining the opening; and

coupling the inflator with the housing by engaging the exterior surface of the collar with at least one engagement structure such that the engagement structure directly engages the collar and such that the engagement structure directly engages the housing to secure the inflator to the housing.

2. The method of claim **1**, wherein the housing comprises an airbag module housing.

3. The method of claim **1**, wherein the collar comprises a groove, wherein the engagement structure comprises a locking ring, and wherein the step of coupling the inflator with the housing comprises positioning the locking ring in the groove.

4. The method of claim **3**, wherein the collar further comprises a second groove, and wherein the step of coupling the inflator with the housing further comprises positioning a second locking ring in the second groove such that a portion of the housing is sandwiched between the locking ring and the second locking ring.

5. The method of claim **1**, wherein the housing comprises an adapter housing configured to facilitate coupling of a flangeless inflator to an airbag module housing.

6. The method of claim **1**, wherein the collar comprises at least one collar engagement structure, and wherein the step of coupling the inflator with the housing comprises engaging the at least one collar engagement structure with the at least one engagement structure.

7. The method of claim **6**, wherein the opening of the housing is at least partially defined by a collar sleeve configured to receive the collar of the inflator, and wherein the step of coupling the inflator with the housing comprises forming a crimp in the collar sleeve to engage the collar.

8. The method of claim **7**, wherein the collar comprises a crimp groove configured to receive the crimp formed in the collar sleeve, and wherein the step of coupling the inflator with the housing comprises forming a crimp in the collar sleeve that engages the crimp groove.

9. The method of claim **1**, wherein the inflator comprises an initiator, and wherein the initiator is at least partially housed within the collar.

10. The method of claim **1**, wherein the at least one engagement structure comprises a retainer clip, and wherein the step of coupling the inflator with the housing comprises engaging the retainer clip with the collar to prevent the collar from being withdrawn from the opening.

11. The method of claim **1**, wherein the step of coupling the inflator with the housing comprises coupling the inflator with the housing without rotating the inflator with respect to the housing.

12. The method of claim **1**, wherein the engagement structure comprises a crimp cap comprising a crimp cap collar and a crimp cap flange, and wherein the step of coupling the inflator with the housing comprises:

inserting the collar of the inflator into the crimp cap collar such that the crimp cap flange is positioned against the housing; and

crimping the crimp cap collar to the collar of the inflator to couple the inflator with the housing.

13. A vehicle airbag assembly, comprising:

an airbag module housing comprising an opening, wherein the airbag module housing comprises an interior surface and an exterior surface opposite from the interior surface;

an airbag cushion positioned within the interior surface of the airbag module housing;

an inflator comprising a collar configured to be received in the opening, wherein the collar is configured to extend at least partially through the opening such that at least a portion of the collar extends out of the opening and is positioned adjacent to the exterior surface of the airbag module housing; and

a retainer clip configured to engage the at least a portion of the collar extending out of the opening to prevent the collar from being withdrawn from the opening after the collar has been positioned such that at least a portion of the collar extends out of the opening, and such that the retainer clip engages the exterior surface of the airbag module housing.

14. The vehicle airbag assembly of claim **13**, wherein the inflator comprises an initiator, and wherein the initiator is at least partially housed within the collar.

15. The vehicle airbag assembly of claim **13**, wherein the retainer clip comprises at least two legs, and wherein the

collar comprises at least one slot configured to receive at least a portion of at least one of the legs.

16. The vehicle airbag assembly of claim **15**, wherein the collar comprises two opposing slots configured to receive two opposing legs of the retainer clip to prevent the collar from being withdrawn from the opening.

17. The vehicle airbag assembly of claim **13**, wherein the retainer clip is configured to resiliently bias the collar with respect to the airbag module housing to prevent the collar from being withdrawn from the opening.

18. The vehicle airbag assembly of claim **17**, wherein the retainer clip comprises an offset portion configured to contact a portion of the airbag module housing adjacent to the opening when the retainer clip is engaged with the collar such that at least a portion of the retainer clip adjacent to the offset portion is spaced apart from a portion of the airbag module housing adjacent to the opening when the retainer clip is engaged with the collar.

19. The vehicle airbag assembly of claim **13**, wherein the collar comprises a projection, and wherein the opening of the airbag module housing comprises a notch configured to receive the projection to align the collar within the opening in a preconfigured rotational position.

20. The vehicle airbag assembly of claim **13**, wherein the inflator comprises a composite fiber overwrap.

21. The vehicle airbag assembly of claim **13**, wherein the retainer clip is configured to engage the collar along a first portion of the retainer clip and to engage the housing along a second portion of the retainer clip.

22. A vehicle airbag assembly, comprising:

a housing comprising an opening at least partially defined by a collar sleeve, wherein the housing comprises an interior surface and an exterior surface opposite from the interior surface;

an airbag cushion coupled with the housing and positioned adjacent to the interior surface of the housing; and

an inflator comprising an inflator collar configured to be received in the opening and to extend into the collar sleeve, wherein the inflator collar comprises at least one crimping feature configured to facilitate fixed engagement between the inflator collar and the collar sleeve, and wherein the collar sleeve is directly coupled to the inflator collar at the at least one crimping feature without the airbag cushion being positioned between the collar sleeve and the inflator collar.

23. The vehicle airbag assembly of claim **22**, further comprising an airbag module housing, wherein the inflator comprises a flangeless inflator, and wherein the housing comprises an adapter housing configured to facilitate coupling of the flangeless inflator to the airbag module housing.

24. The vehicle airbag assembly of claim **22**, wherein the inflator comprises a composite fiber overwrap.

25. The vehicle airbag assembly of claim **22**, wherein the collar sleeve comprises a poka yoke feature, and wherein the inflator collar comprises a corresponding poka yoke feature configured to facilitate engagement of the inflator collar within the collar sleeve in a preconfigured rotational position.

26. The vehicle airbag assembly of claim **22**, wherein the at least one crimping feature comprises a crimp groove configured to engage a crimp formed in the collar sleeve.

27. The vehicle airbag assembly of claim **22**, wherein the housing is configured such that, upon engagement of the inflator with the housing, at least one air gap is formed between the inflator and the housing.

28. The vehicle airbag assembly of claim **27**, wherein the housing comprises a plurality of ribs formed within an inner surface of the housing configured to contact the inflator such that a plurality of air gaps are formed between the inflator and the housing in between the ribs.

29. The vehicle airbag assembly of claim **22**, wherein the at least one crimping feature is configured to facilitate fixed engagement between the inflator collar and the collar sleeve without requiring any additional locking components or elements to accomplish the fixed engagement.

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